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Abel & Imray

(54) Hand operated piston pump

(57) In a hand-operated container-mounted piston pump, e.g. for cosmetics, the piston 5 and cylinder 8 have co-operating ports 16, 18, A, E to function as a slide valve controlling intake and delivery of liquid and air, there being no communication between the pump inlet and outlet in the rest position of the pump. The piston may be reciprocable and the cylinder fixed, or vice versa. Actuation may be by press button or trigger.

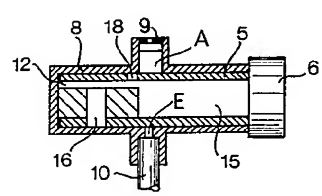

FIG.1a

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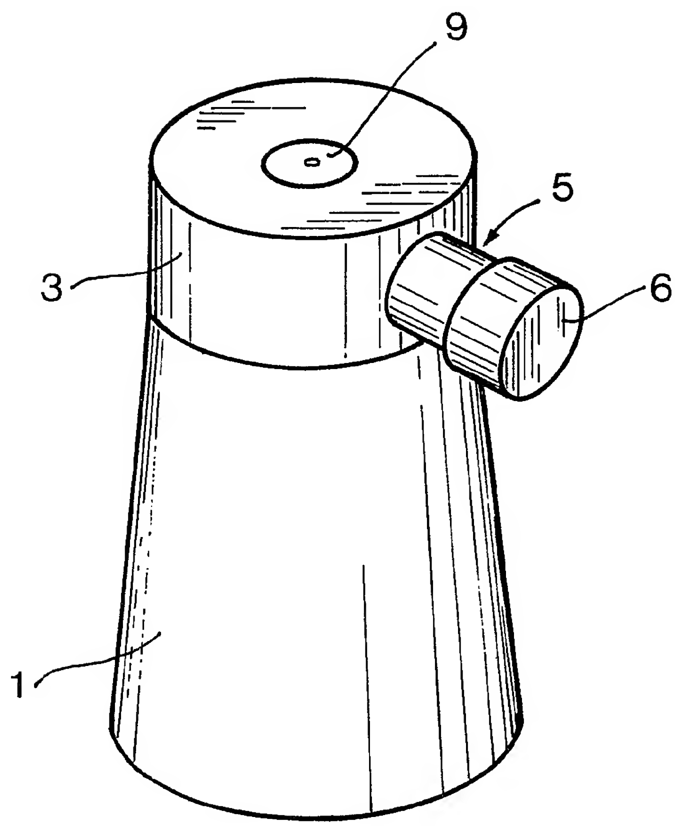

FIG. 1

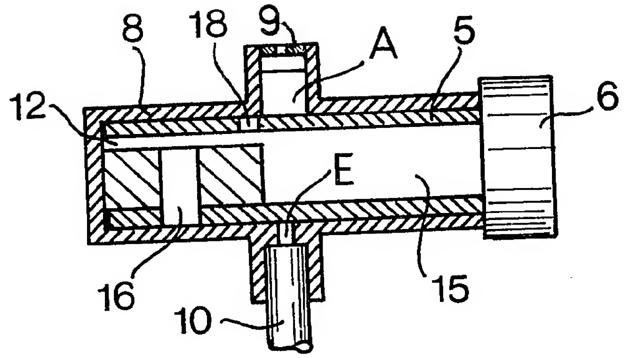

FIG.1a

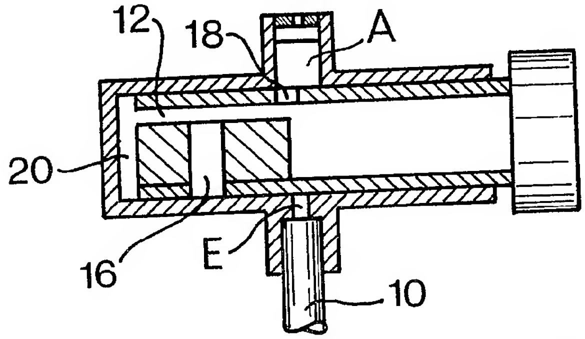

FIG.1b

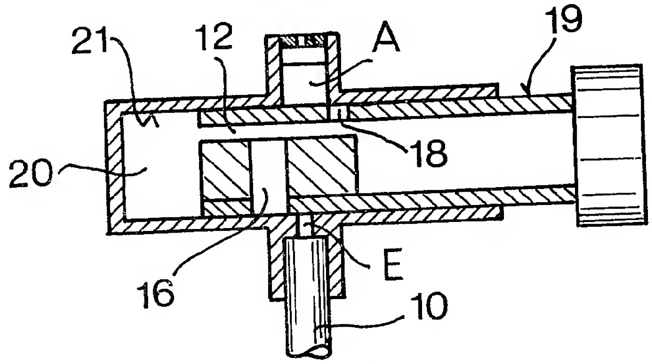

FIG.1c

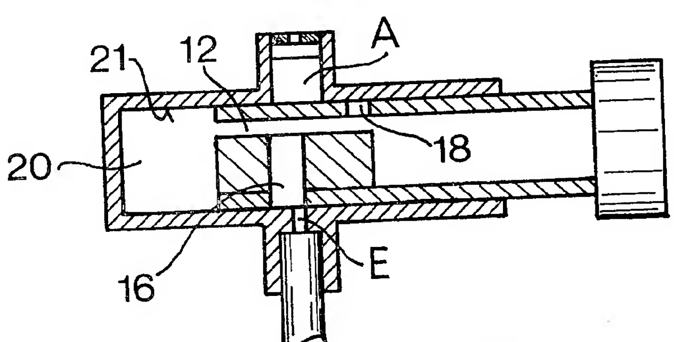

FIG.1d

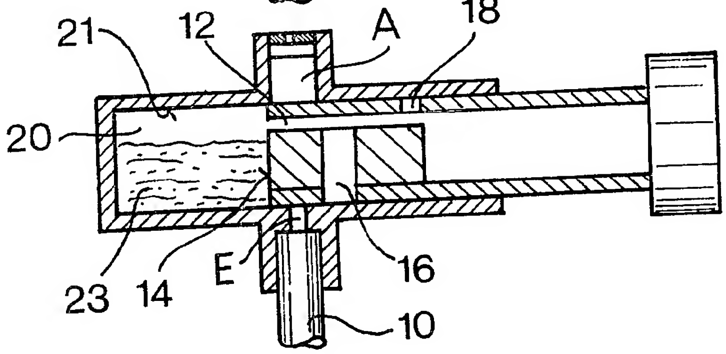

FIG.1e

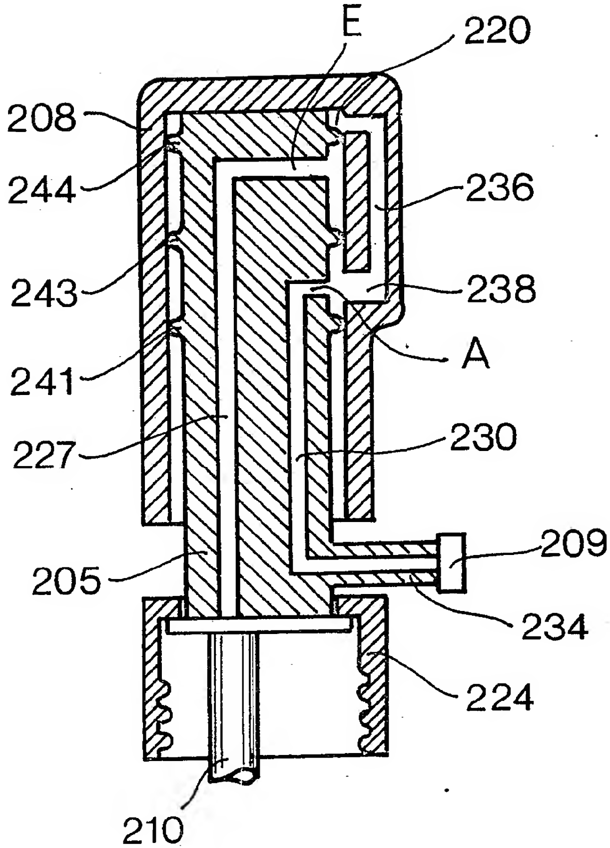
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FIG. 2a

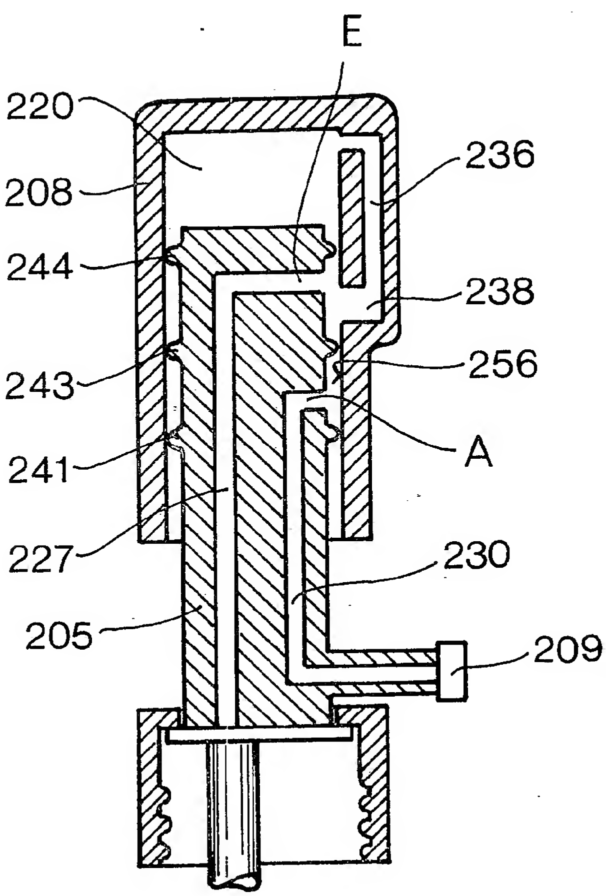
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FIG. 2b

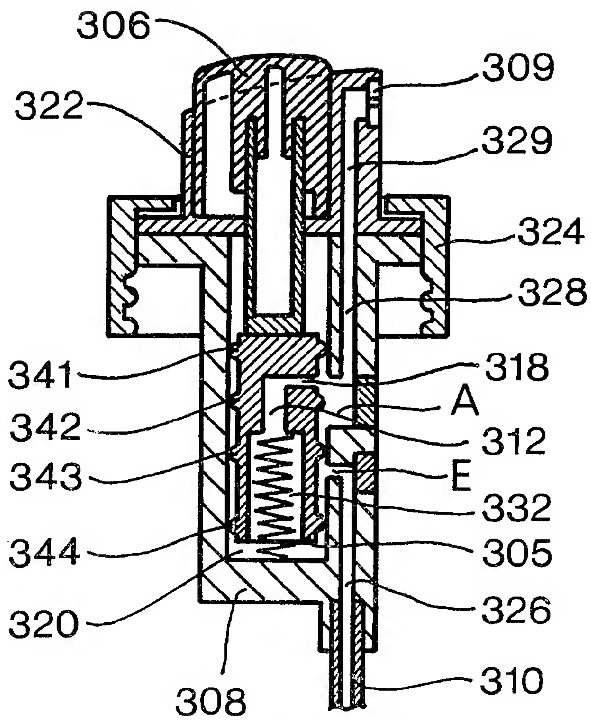


FIG.3a

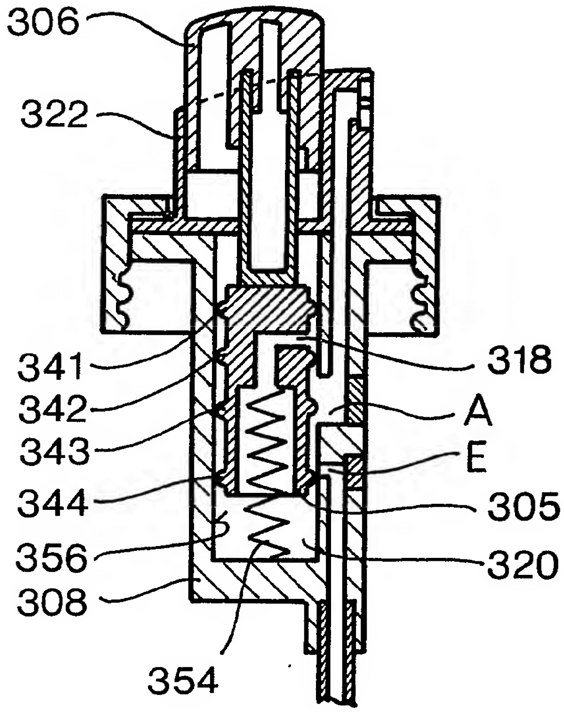


FIG.3b

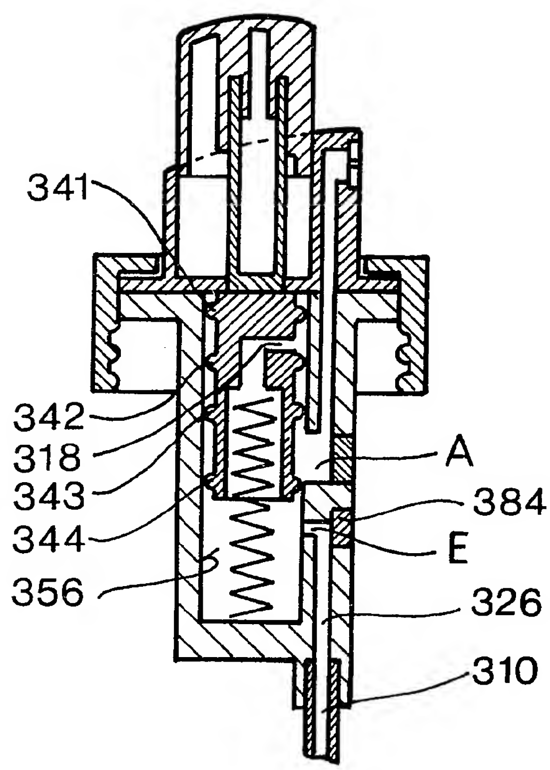
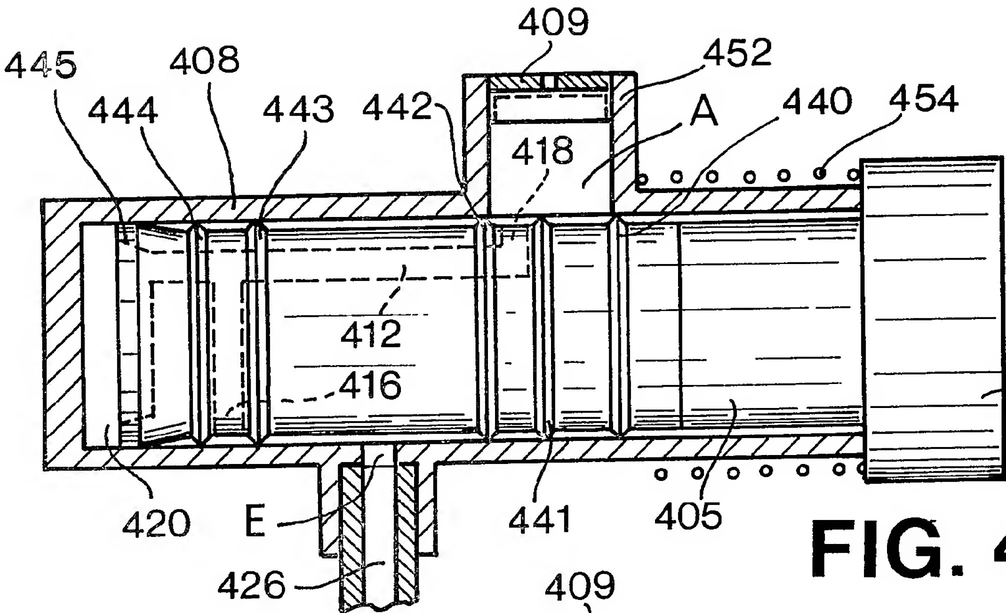


FIG.3c



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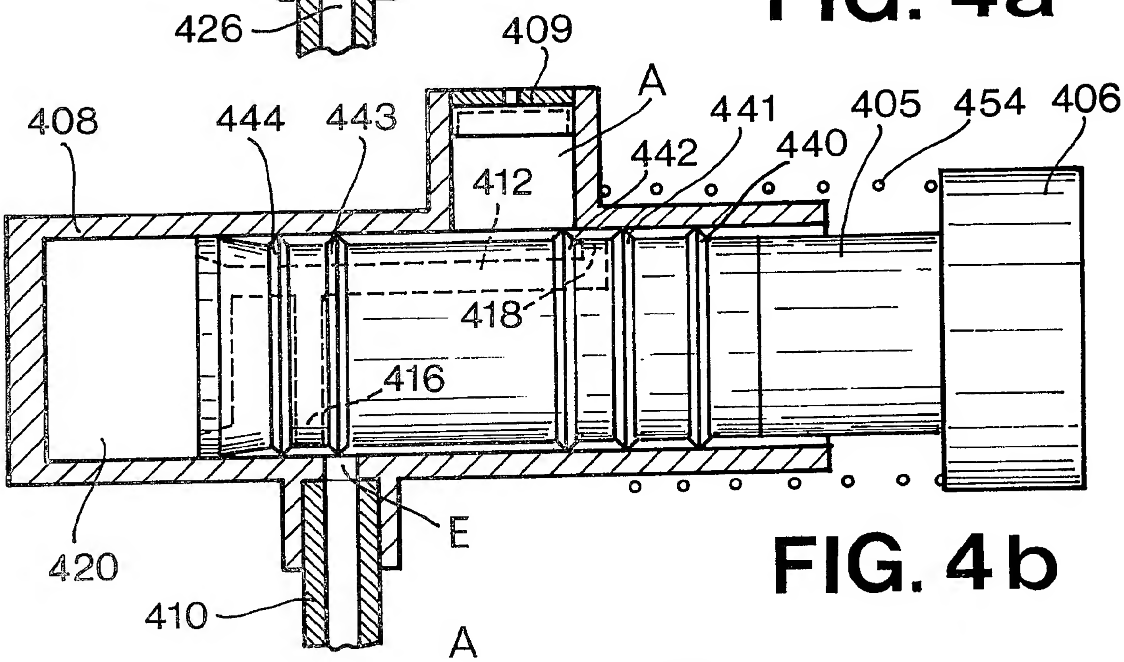

FIG. 4b

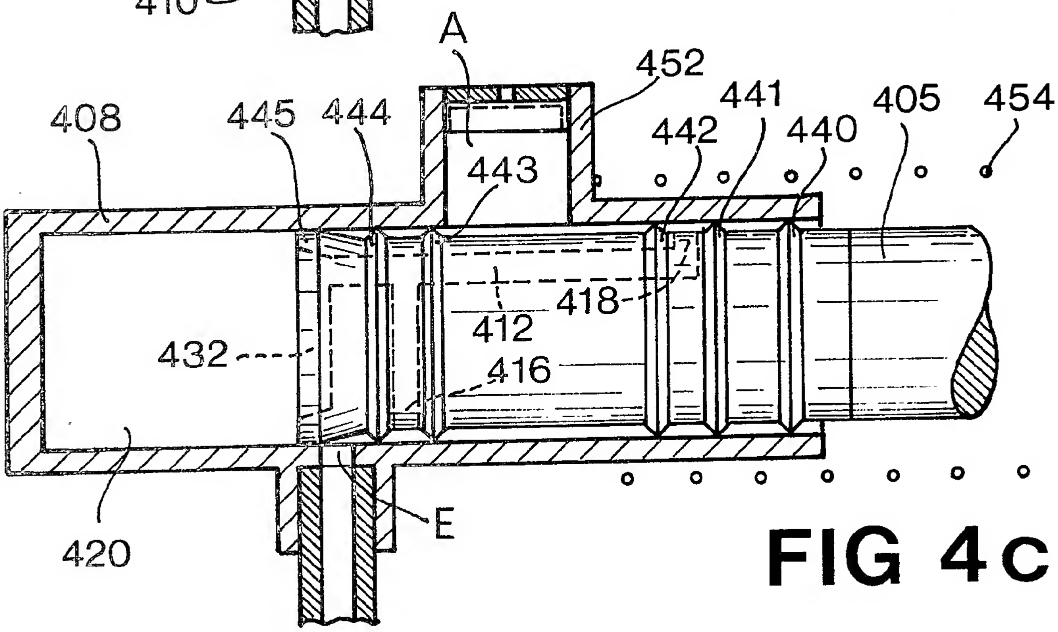

FIG 4c

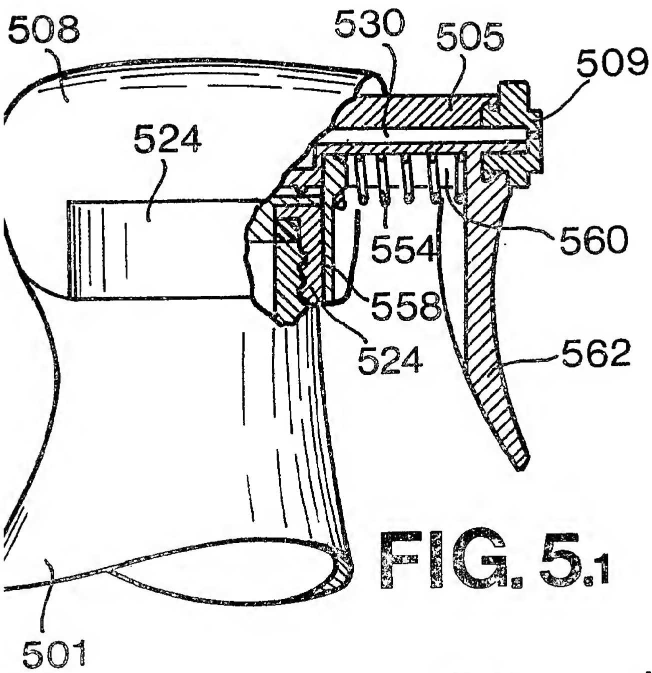

FIG. 5.1

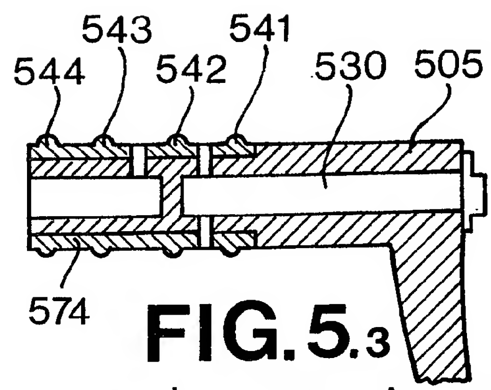

FIG. 5.3

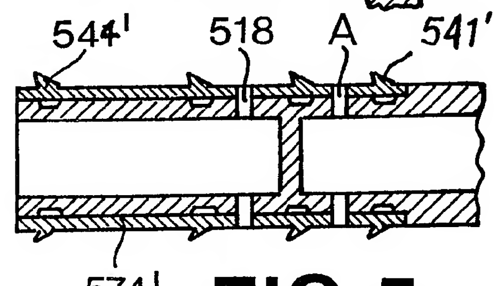

FIG. 5.6

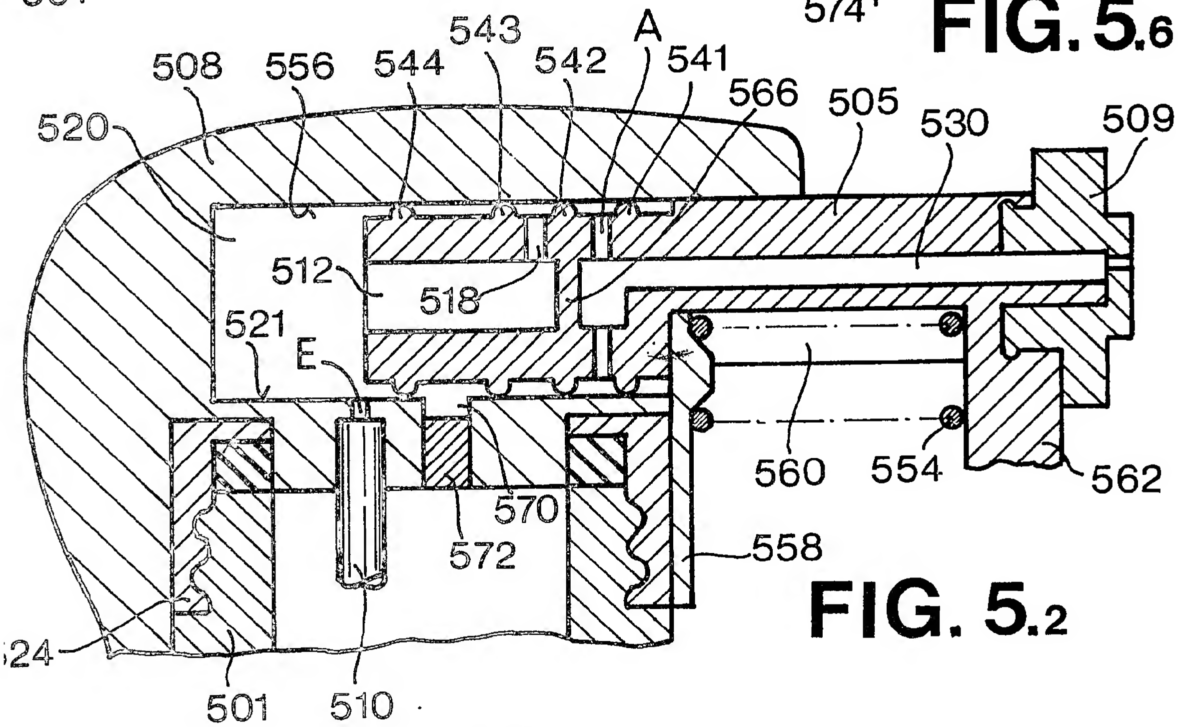

FIG. 5.2

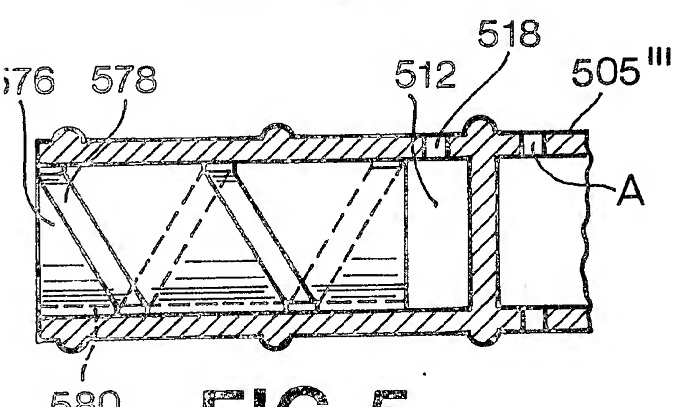

FIG. 5.5

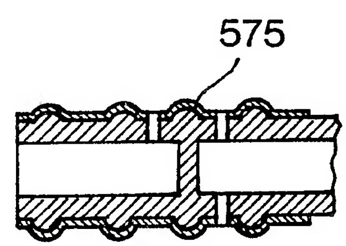

FIG. 5.4

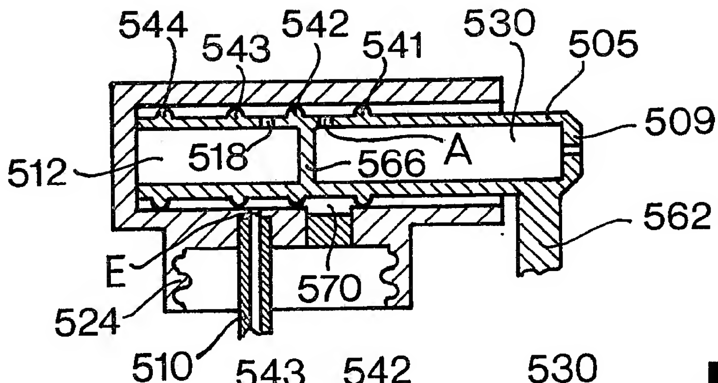

FIG.5a

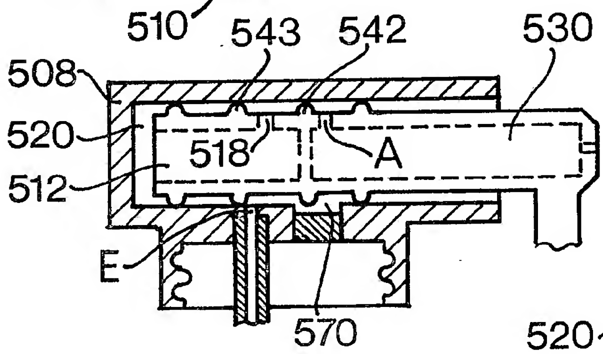

FIG.5b

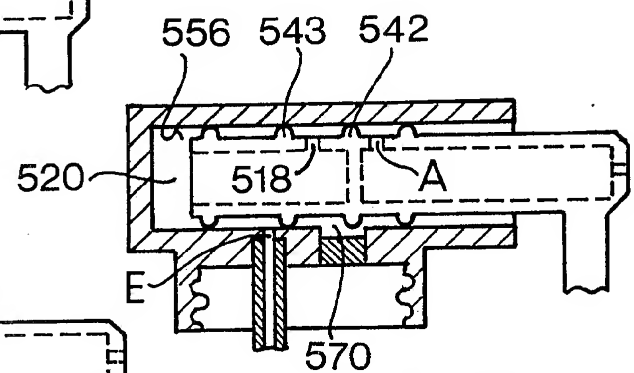

FIG.5c

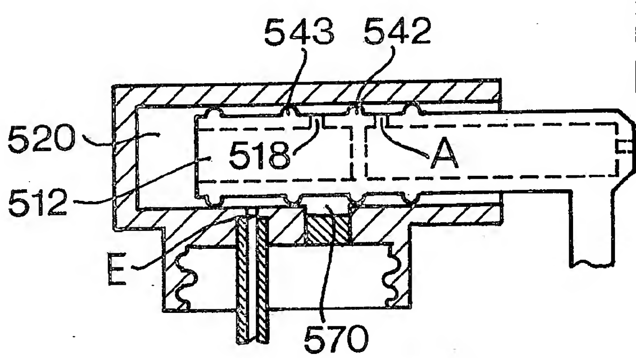

FIG.5d

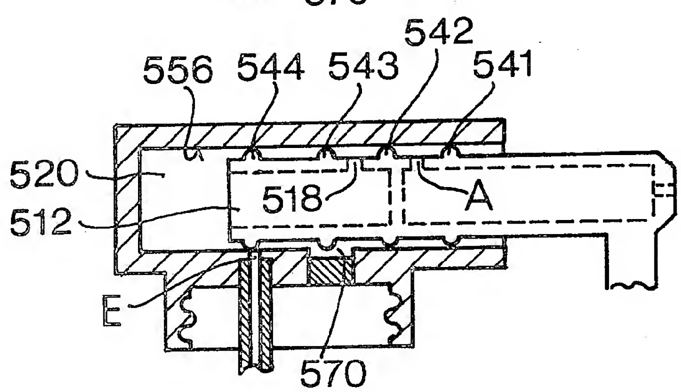

FIG.5e

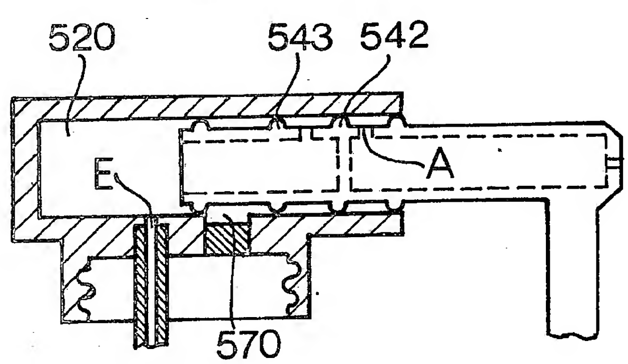

FIG.5f

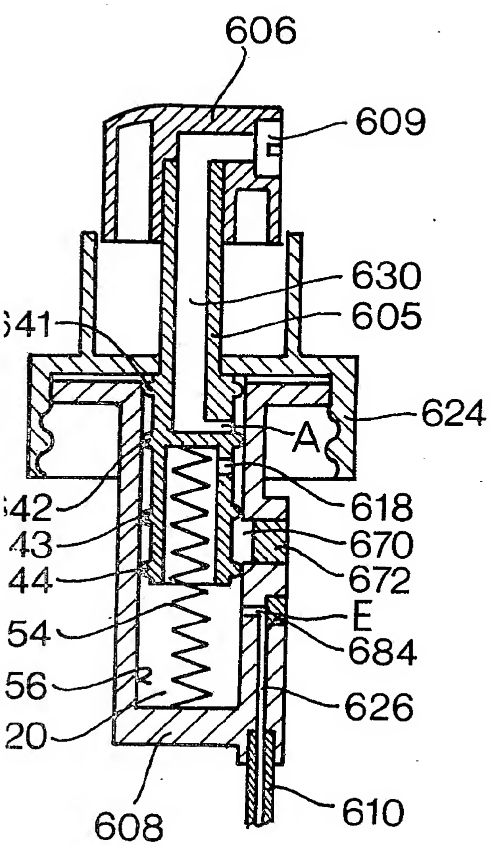

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FIG. 6

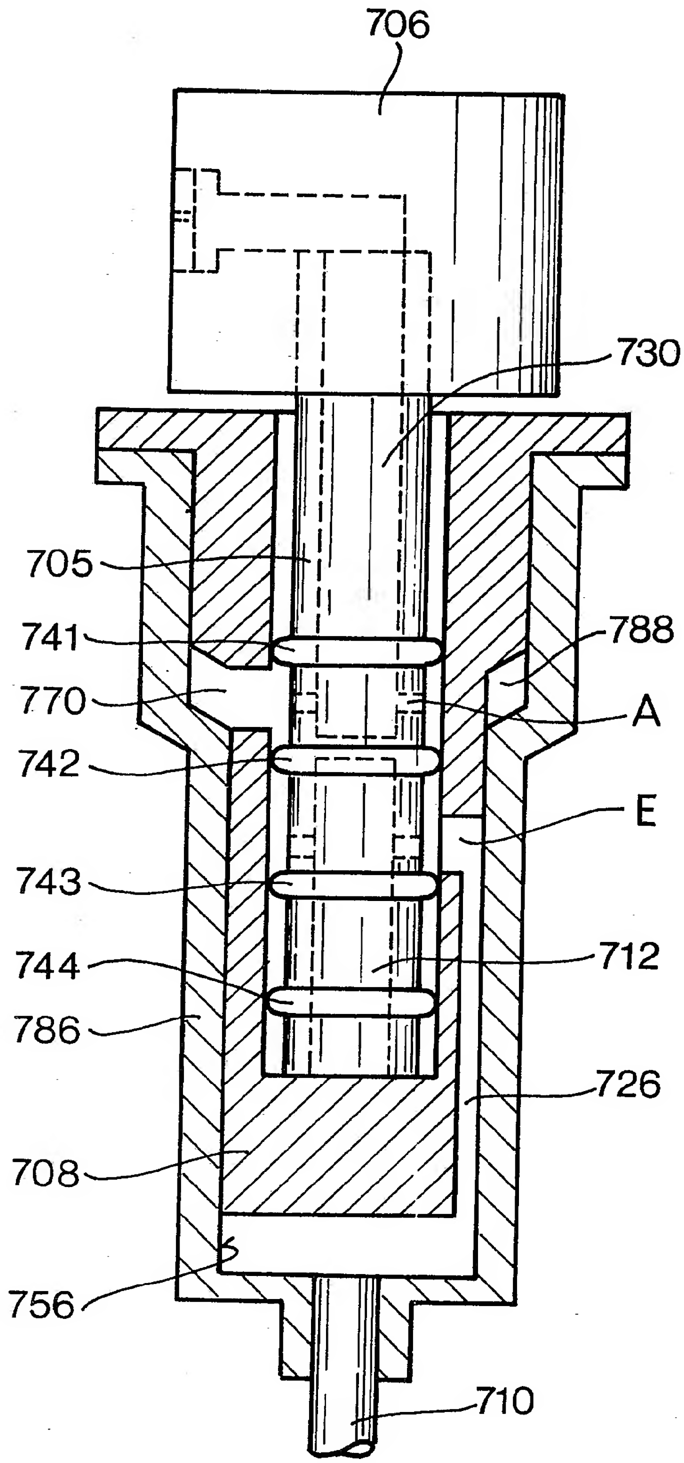

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FIG. 7

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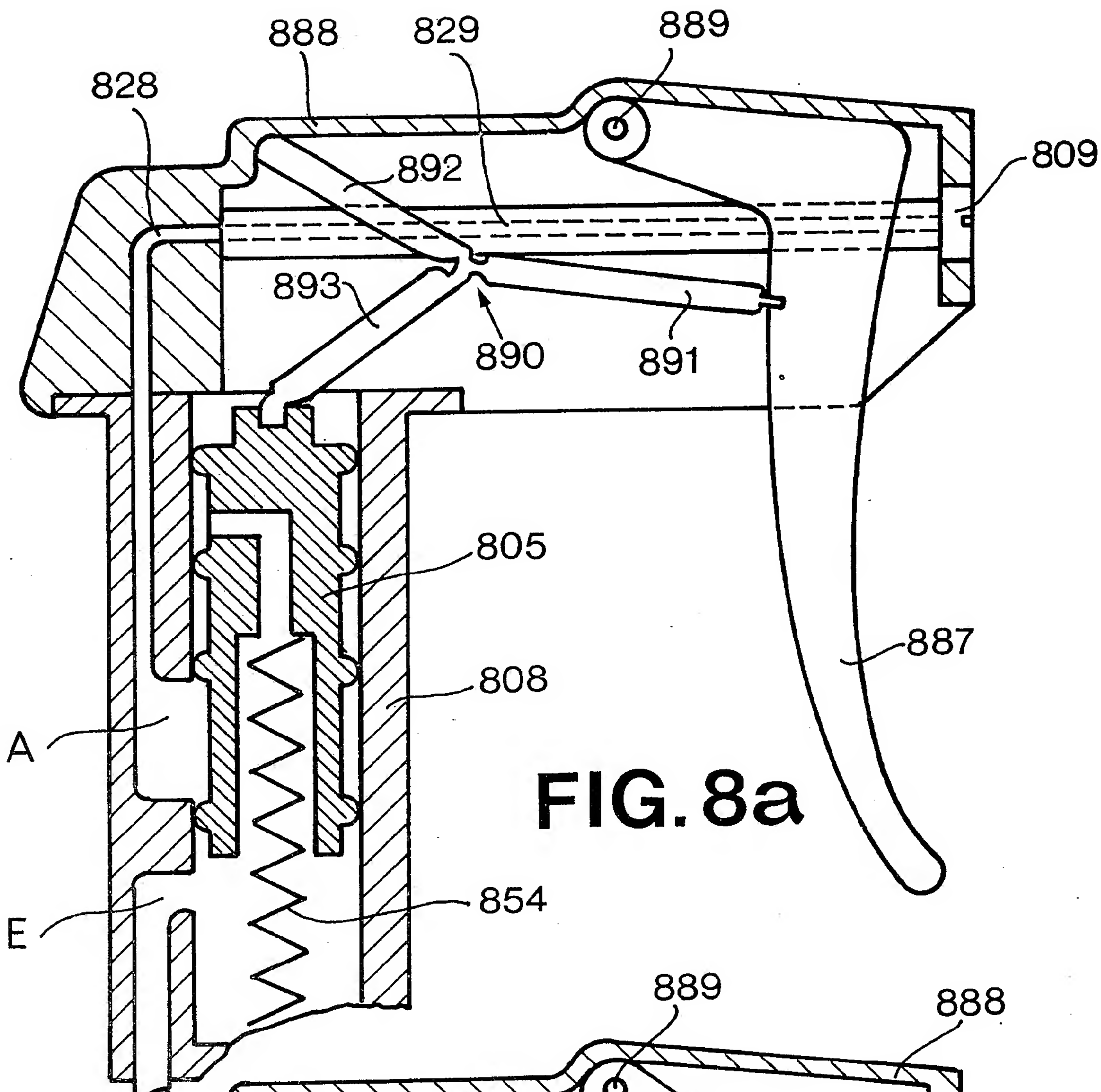

FIG. 8a

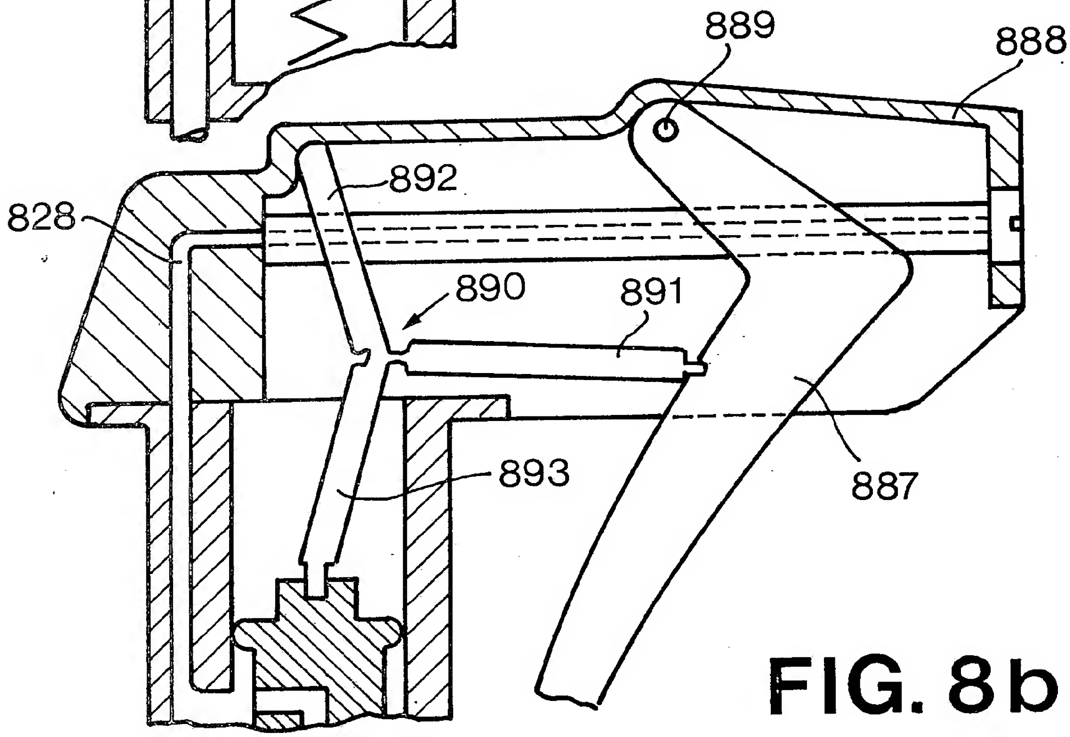

FIG. 8b

SPECIFICATION

Hand-operated axial piston pump

The present invention relates to a hand-operated axial piston pump that is suitable for discharging the contents of a container and that simultaneously serves, in its rest position, as a closure for the container. Such pumps are, for example, particularly useful for discharging cosmetic products or cleaning agents, in the form of a jet, a spray mist, or a foam.

Hand-operated axial piston pumps previously used for discharging such products have been provided with non-return valves, but this necessitates a relatively large number of components and means that the costs of manufacture and assembly can be relatively high. Moreover, pumps fitted with non-return valves are often susceptible to breakdown as a result of the non-return valves becoming jammed, stuck or fouled in some other way. Such pumps generally discharge the liquid contents of the container without admixing air with it, this can, however, cause difficulties if it is desired to spray the liquid, because spraying is, in this case, possible only by mechanically breaking the liquid down into individual droplets, whereas the spray mist formed in this manner is not adequately fine for all purposes.

Axial piston pumps operating without non-return valves are used in mechanical engineering and in certain other fields, but these pumps generally contain additional parts such as slide-members for the purpose of control or means for rotating the piston. Pumps of this kind cannot, however, economically be mass-produced as hand-operated pumps.

The present invention provides a hand-operated axial piston pump suitable for discharging the contents of a container, which pump includes an inlet through which material from the container can enter the pump and an outlet through which the said material can be discharged, each of the inlet and the outlet opening through an aperture in the outer wall of the pump piston or the inner wall of the pump housing into the interior of the pump housing, wherein one or more passages opening into the interior of the pump housing and each of the inlet aperture and the outlet aperture are so arranged in the piston or in the housing that the piston and the housing form an axial piston valve whereby the inlet and outlet apertures open and close at various portions of the pump stroke and whereby, when the pump is in its rest position, there is no communication between the inlet and the outlet.

The pump need, in general, contain only one moving part, namely either the piston or the housing, although certain moving levers or other means may also be used to actuate the pump. As is customary in axial piston valves, no additional parts are required to control the various flow paths, control being effected by means of control edges of apertures that can be displaced with respect to one another or control edges of annular seals that can be displaced with respect to apertures.

In a pump according to the invention, the relative movement between the piston and the housing is preferably substantially purely translational movement, that is to say, it is preferably solely a displacement movement with no rotational movement. This is in contrast with the above-mentioned pumps used in mechanical engineering, in which there is also rotational movement.

The pump according to the invention may be of very simple construction and has the important advantage that, because the piston and housing serve not only as a pump but, also as a valve, the pump does not require a separate non-return valve: the pump itself serves, in its rest position, as a closure for any container to which it is attached. This may conveniently be achieved by so arranging the outlet and the passage or passages within the pump that, in the outermost portion of the pump stroke, there is no communication between the outlet and the pump chamber. The outermost position of the piston will generally be the rest position, and the pump may be provided with a return spring which serves to urge the piston into its outermost position. Such a spring may be situated in any convenient position, for example within the pump chamber, or external of the pump housing and around or alongside the pump housing and around or alongside the piston.

It is also possible for the pump to act as a closure for a container to which it is attached when the piston is in its innermost position. This can be advantageous during transport of the pump, because in order to save space the piston may be pushed in completely and locked in this position and the contents of the container cannot then escape. Thus, the passage or passages within the pump and the inlet may be so arranged that, in the innermost portion of the pump stroke, there is no communication between the inlet and the pump chamber.

The pump may also provide for aeration of the container to replace the discharged contents, with the aeration passage passing not directly from outside into the container, as the contents might then leak out during transport of the container, but passing through the pump such that it is closed in the rest position. To this end, the passage or passages within the pump and the inlet and the outlet may be so arranged that, in one portion of the pump stroke, the inlet is in communication with the outlet through the pump chamber. Air can thus pass through the pump directly into the container in one portion of the pump stroke. Alternatively, the arrangement may be such that, in one portion of the pump stroke, the outlet is in communication with the pump chamber and, in a second portion of the pump stroke, which is an outer portion with respect to the first-mentioned portion, the inlet is in communication with the pump chamber. In this case, the container can be aerated by air passing into the pump chamber in one portion of the pump stroke and into the container in another portion of the stroke.

The pump can thus use the surrounding air for the pumping operation: with each piston stroke, not only is material from the container (usualoy liquid) conveyed in the intended direction, that is, from the container into open air, but, in contradistinction to conventional pumps, air is sucked from outside into the pump chamber, and air and, to some extent, also

the said material, are conveyed from the pump chamber into the container. The pump thus operates in a manner that has purposely been avoided in conventional pumps in which replacement air generally by-passes the pump system and flows directly into the container, but this manner of operation can give important advantages. Chiefly, it means that the pump can be of particularly simple construction. Also, air sucked through the passages of the pump can clean these passages, this being of particular importance in the case of tacky materials and materials that tend to form crusts on the surfaces. The connecting passage between the container and the pump chamber can be cleaned in a similar manner. Moreover, air is conveyed through the pump system back into the container to replace the material that has been discharged.

Moreover, the pump according to the invention may be used to spray liquid admixed with air, and thus it may be used as an alternative to an aerosol spray. The pump may also be used to discharge, especially in the form of a spray, the contents of the container under excess pressure.

The passages and the inlet aperture and the outlet aperture can be so arranged that, in one portion of the pump stroke, there is no communication between the outlet and the pump chamber nor between the inlet and the pump chamber. This arrangement ensures that excess pressure is produced during one portion of the pressure stroke, and that the connection between the pump chamber and the outlet opens only when this excess pressure has built up, where-upon material is abruptly discharged, thus giving an improved spray action. During movement of the piston in the opposite direction, a reduced pressure is produced in the pump chamber before material is sucked from the container, with the result that, when the connection between the pump chamber and the inlet opens, material abruptly passes from the container into the pump chamber, which assists in cleaning the connecting passage between the container and the pump chamber.

In pumps in which an excess or reduced pressure is produced in this manner during part of the pump stroke, the pump chamber is advantageously prevented from becoming completely filled with material from the container since this could prevent further movement of the piston. It is therefore advantageous to provide a compressible medium situated in the pump chamber or in a chamber immediately adjoining the pump chamber. This compressible medium may be air or may be a sponge or foam material having closed pores. Alternatively, a wall of the pump chamber or of a chamber immediately adjoining the pump chamber may include a resilient wall portion.

If, in one portion of the pump stroke, there is no communication between the outlet and the pump chamber, nor between the inlet and the pump chamber, but the formation of excess and reduced pressures is not desired, then a leakage seal may be provided between the piston and the housing, that will permit a leakage flow sufficient to maintain pressure equalisation.

In a pump according to the invention, the inlet and outlet may be arranged in two principally different ways in the two pump parts, that is, the pump piston and the pump housing. The inlet and the outlet may be provided both in the pump piston or both in the pump housing; pumps of this type will hereinafter be referred to as "pumps of the first kind". If both the inlet and the outlet are provided in the housing, which may be secured to the container, pumping may be achieved by moving the piston by hand with respect to the housing, in which case the outlet, to which a nozzle may be attached, remains stationary, this being preferred for many fields of use. The same result may be achieved if both the inlet and outlet are provided in the piston and the piston is secured to the container; in this case, the housing may be moved by hand with respect to the piston and the outlet, provided in the piston, remains stationary.

Alternatively, one of the inlet and the outlet may be provided in the housing while the other is provided in the piston. The part including the inlet, either the piston or the housing, will normally be secured to the container, while the other part, including the outlet, will be operated by hand. In these cases, the outlet takes part in the pump movement. Pumps of this kind will hereinafter be referred to as "pumps of the second kind" and have the advantage of being especially easy to manufacture.

In pumps according to the invention, because the sole connection between a container to which the pump is attached and the outside passes through the pump system, and therefore liquid can leave and air can enter only through the mouth of the outlet passage, the pump itself reliably seals the container from the outside. At least in the state of rest when the piston is in its outermost position and, if desired, also when the piston is in its innermost position, the mouthpiece is sealed off from the inside of the container.

In a pump of the first kind, the inlet and the outlet are situated both in the piston or both in the housing, and a passage may be provided in the other end of the piston and the housing such that, in one portion of the pump stroke, the inlet is in communication with the pump chamber *via* the said passage and in the same or another portion of the pump stroke, the outlet is in communication with the pump chamber *via* the said passage. The inlet and outlet apertures are preferably offset longitudinally with respect to one another.

When the inlet and the outlet are both provided in the housing, the said passage may extend longitudinally within the piston from the pump chamber to two apertures in the side wall of the piston, one passage aperture for communication with the inlet aperture in one portion of the pump stroke and the second passage aperture for communication with the outlet aperture in the same or another portion of the pump stroke. Alternatively, the said passage may extend longitudinally from the pump chamber to an aperture in the side wall of the piston, which aperture communicates with the inlet aperture and/or the outlet aperture in various portions of the pump stroke.

In this latter case, first, second and third annular seals may be provided between the outer wall of the

piston and the inner wall of the housing, wherein the first seal is the outermost seal and serves to seal off the interior of the housing from the exterior of the pump in all portions of the pump stroke, wherein the passage aperture lies between the first seal and the second seal, wherein the second seal is so situated that in a first portion of the pump stroke it separates the inlet aperture from the outlet aperture, and wherein the third seal is the innermost seal and is so situated that in a second portion of the pump stroke, which is an outer portion with respect to the said first portion, it separates the inlet aperture from the outlet aperture while the inlet is in communication with the pump chamber, and that in another portion of the pump stroke, which is an inner portion with respect to the said second portion, it separates the inlet aperture from the pump chamber.

The annular seals are preferably provided on the piston with the first and third seals adjacent to the outer and inner ends of the piston respectively, with the first seal so situated that, in all portions of the pump stroke, it is outward of the outlet aperture. Advantageously, the distance between the first and third seals is greater than the distance between the edges of the inlet aperture and the outlet aperture that are furthest from one another. Moreover, advantageously, the distance between the first and second seals is less than the distance between the edges of the openings of the inlet aperture and the outlet aperture that are furthest from one another. The second and third seals are so situated that, in one portion of the pump stroke, while the third seal seals off the inlet aperture from the pump chamber, the inlet is in communication with the outlet. A fourth annular seal may be provided between the third seal and the passage aperture; the provision of such a fourth seal can shorten the length of stroke over which the outlet is in communication with the pump chamber and thus can assist in the formation of excess or reduced pressure within the pump chamber.

The passage within the piston may connect with a second aperture in the side wall of the piston, which second aperture is situated between the first aperture and the inner end of the piston, preferably between the second and third annular seals.

When the inlet aperture and the outlet aperture are both provided in the side wall of the piston, the two apertures being offset longitudinally wiht respect to one another, with a passage extending longitudinally within the housing from the pump chamber to an opening in the inner wall of the housing, the arrangement may be such that, in a first portion of the pump stroke, the outlet is in communication with the said passage and, in a second portion of the pump stroke, which is an outer portion with respect to the first portion, the inlet is in communication with the said passage and there is no communication between the outlet and the said passage. Preferably, three annular seals are provided on the piston in such positions that the inlet aperture is situated between the innermost and middle seals and the outlet aperture is situated between the outermost and middle seals.

In a pump of the second kind, the inlet and the outlet are provided one in the piston and one in the housing, and a passage or recess, each opening into the interior of the housing, may be provided in each of the piston and the housing, such that in one portion of the pump storke the inlet is in communication with the pump chamber and in the same or another portion of the pump stroke the outlet is in communication with the pump chamber. One such passage may extend from the pump chamber through the piston or housing to an aperture opening into the interior of the housing, while a second such passage extends through the other of the piston and the housing and connects two apertures opening into the interior of the housing, or while a recess is provided in the wall of the other of the piston and the housing. Advantageously, one such passage extends longitudinally through the piston from the pump chamber to an aperture in the wall of the piston, while a recess is provided in the wall of the housing. In this case, the inlet or, preferably, the outlet advantageously also opens through an aperture in the wall of the piston, which aperture may be separated from the passage aperture by an annular seal. The recess is preferably so arranged that in one portion of the pump stroke, the passage aperture is in communication with the outlet aperture *via* the recess. In a second portion of the pump stroke, the passage aperture is preferably in communication with the inlet *via* the recess. Moreover, in a third portion of the pump stroke, the inlet may be in communication with the outlet aperture *via* the recess.

The pump may be provided with at least four annular seals between the outer wall of the piston and the inner wall of the housing. These are advantageously provided on the piston. The first and fourth annular seals are preferably situated adjacent to the outer and inner ends of the piston respectively, with the outlet aperture situated between the first and second annular seals and the passage aperture situated between the second and third annular seals. Preferably, in all portions of the pump stroke the first seal is outward of the recess and the fourth seal is inward of the recess. The distance between the first and third seals is preferably greater than the distance between the edges of the inlet aperture and the recess that are furthest from one another. While the distance between the second and third seals is preferably greater than the distance between the edges of the inlet aperture and the recess that are nearest to one another.

In a pump according to the invention, the housing may comprise an inner housing fitted snugly within an outer housing, with any apertures, recesses and/or passages in the housing being constituted by bores and/or grooves in the inner housing and/or by gaps between the inner and outer hosuings. This has the advantage that the housing, with its various apertures, passages and recesses, may be easily constructed.

The present invention also provides a unit comprising a container and a pump according to the invention secured thereto by whichever of the pump housing and the pump piston contains the inlet, the inlet being in communication with the interior of the

container.

In such a unit, the pump may be actuated by a push-button attached to or constituted by, or by a trigger attached to, whichever of the pump piston and the pump housing is not secured to the container. Alternatively, it may be actuated by a trigger mechanism including means for converting the pivotal movement of the trigger to movement of the piston or housing. Such means may suitably comprise a Y-shaped member of a resilient plastics material having three arms flexibly joined together, with one arm secured to the trigger, one arm secured to the piston or housing, and one arm secured to a mounting.

Various pumps according to the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic perspective view of a container provided with a hand-operated axial piston pump according to the invention;

Figures 1a to 1e are schematic longitudinal sectional views (showing various portions of a piston stroke) of a pump suitable for use on the container shown in Figure 1;

Figures 2a and 2b are schematic longitudinal sectional views (showing various portions of a piston stroke) of a further pump according to the invention;

Figures 3a to 3c are schematic longitudinal sectional views (showing various portions of a piston stroke) of another pump according to the invention;

Figures 4a to 4c are schematic side views, partly in longitudinal section (showing various portions of a piston stroke) of a pump similar to that shown in Figures 1*a* to 1*e*;

Figures 5.1 and 5.2 are schematic side views, partly in longitudinal section, of yet another form of pump according to the invention;

Figures 5.3 to 5.6 are schematic longitudinal sectional views of modified versions of part of a pump as shown in Figures 5.1 a dn5 2;

Figures 5a to 5f are schematic longitudinal sectional views (showing various portions of a piston stroke) of a pump similar to that shown in Figures 5.1 and 5.2;

Figures 6 and 7 are schematic longitudinal sectional views of two further forms of pumps according to the invention; and

Figures 8a and 8b are schematic views, partly in longitudinal section, of an operating mechanism for use in conjunction with a pump according to the invention.

(Throughout the description of the drawings, all references to "top", "bottom", "left", "right", "upward", "downward", and like positional and direction terms refer merely to the position of the pump as shown in the respective drawing and are not to be construed as meaning that the pump must necessarily be used in that position.)

(Throughout the drawings, the last two digits of all reference numerals denote like parts in the various pumps, whereas the "hundreds" digit (where present) indicates the figure or series of figures; that is to say, reference numerals in the series commencing 201 refer to Figures 2*a* and 2*b*, reference numerals in the series commencing 301 refer to Figures 3*a* to 3*c*, and so on.)

Referring to Figure 1, a container 1 suitable for containing material to be discharged, especially a liquid, includes a closure cap 3 having a mouthpiece 9, which may be in the form of, for example, a nozzle. The closure cap 3 accommodates the housing (not visible) of a pump according to the invention and a portion of the piston 5 of the pump projects from the cap 3 and is provided with an operation button 6.

The arrangement of the pump housing 8 and the piston 5 are shown in detail in Figures 1*a* to 1*e*, from which it may be seen that this is a pump of the first kind with both the inlet and the outlet provided in the housing. The housing is provided with an inlet E at the bottom and an outlet A at the top. (Throughout the drawings, the letters E and A refer to the apertures or wall openings in the housing or in the piston, the rims of which apertures form control edges. The letters E and A do not refer to the passages adjoining these apertures.) The inlet E is in communication with a suction pipe 10 which leads into the container 1, and the outlet A is in communication with the mouthpiece 9 provided in the cap 3 (Figures 1 and 1*a*). An overflow channel 12 in the top of the piston 5 leads from the inner end face 14 of the piston 5, parallel to the longitudinal axis of the pump, to a chamber 15 within the piston 5. A compressible medium, such as a sponge with closed pores, may be housed in the chamber 15. The overflow channel 12 is connected by two transverse passages 16 and 18 to the outer wall 19 of the piston. The transverse passage 18 is located at the right-hand end of the overflow passage 12 and leads upward, while the transverse passage 16 is located further to the left and leads downwards. The rims of the outlet A and the inlet E at the inner wall 21 of the housing 8 and the rims of the transverse passages 16 and 18 at the outer wall 19 of the piston 6 constitute control edges.

Figures 1*a* to 1*e*, taken in that order, show various stages of a suction stroke, and, taken in the opposite order, show various stages of a pressure stroke. Figure 1*a* shows the innermost position of the piston 5 and Figure 1*e* shows its outermost position. The piston 5 is prevented from emerging further by means not shown. Moreover, a spring (not shown) serves to urge the piston into the position shown in Figure 1*e*, which accordingly is the rest position of the pump.

The sequence of operation of the pump will now be described, with an outward movement from the position shown in Figure 1*a* to the position shown in Figure 1*e*. The transverse passages 16 and 18 are initially in communication with neither the inlet E nor the outlet A, respectively (Figure 1*a*). As the piston 5 is moved to the right, the pump chamber 20 is first formed and then extended, and the transverse passage 18 moves into a position where it is in communication with the outlet A (Figure 1*b*). As this happens, air is sucked through the outlet A into the pump chamber 20, and any material from a preceding pumping operation which may be adhering to the mouthpiece 9, to the outlet A, or to a relatively long outlet passage which may be provided between the mouthpiece 9 and the outlet A, is removed by this air. On further outward movement of the piston 5, the transverse passage 18 moves out of com-

munication with the outlet A, while the transverse passage 16 still remains out of communication with the inlet E (Figure 1*e*); this is the case, however, only for a fleetingly small portion of the stroke. (The transverse passages 16 and 18, the inlet E and outlet A may, alternatively, be so arranged that both transverse passages 16 and 18 remain closed for a considerable portion of the stroke. In this case, a reduced pressure is caused in the pump chamber 20 during the outward movement of the piston 5 and, during the inward movement to be described hereinafter, an excess pressure is caused.) On further outward movement of the piston 5, the transverse passage 16 moves into communication with the inlet E, while the transverse passage 18 remains out of communication with the outlet A (Figure 1*d*). Liquid is now sucked through the suction pipe 10 into the pump chamber 20 *via* the overflow passage 12. (If a reduced pressure has been formed in the pump chamber prior to this, then this sucking action occurs abruptly.) When the piston has reached its outermost position (Figure 1*e*), both transverse passages 16 and 18 are again out of communication with the inlet E and the outlet A respectively, and the inlet E and the outlet A are also not in communication with the pump chamber 20. This position is the rest position and the transport position of the pump. In this position, both the contents of the container 1 and the contents of the pump chamber 20 are sealed off from the outlet A. Liquid had previously been removed from the outlet A during the stage shown in Figure 1*b* and consequently, in the position shown in Figure 1*e*, no liquid can emerge during the transport of the container 1 with the attached pump. In this position, the pump chamber 20 is only partially filled with liquid 23, such that, when the pump is in a horizontal position, the surface of the liquid 23 lies below the opening of the overflow passage 12 in the end face 14 of the piston 5.

As the piston 5 is pushed inward, from the position shown in Figure 1*e* to the position shown in Figure 1*a*, the contents of the pump chamber 20 and the passages 12, 16 and 18, are initially compressed until the transverse passage 16 opens into communication with the inlet E (Figure 1*d*), whereupon air, and possibly a portion of the liquid 23, is pushed out of the pump chamber 20, through the passages 12 and 16, the inlet E and the suction pipe 10, back into the container 1. The entire suction passage is thereby cleaned and any particles that may have accumulated at constricted points and that may block the suction passages are thereby conveyed back into the container. As the piston is moved further inward, the transverse passage 16 becomes closed off from the inlet E, while the transverse passage 18 is still closed off from the outlet A (Figure 1*c*) and, during this stage, excess pressure is produced in the pump chamber 20. As the wall opening of the transverse passage 18 slides across the outlet A (Figure 1*b*), the contents of the pump chamber 20 are expelled through the outlet A. Finally, in the innermost position of the piston 5k, the transverse passage 18 is again closed off from the outlet A (Figure 1*a*).

The embodiment shown in Figures 1 and 1*a* to 1*e* may be operated even when the container 1 is tilted in such a manner that its longitudinal axis is horizontal and the operating button 6 is uppermost.

Once the pump has been brought into an operational state by means of a few pumping actions, it remains permanently ready for operation. In the rest position shown in Figure 1*e*, the pump chamber 20 contains liquid 23, and when the piston 5 is pushed in liquid 23 is expelled immediately. (This applies also to the other forms of pump which are described below.)

The volume of liquid expelled from the container 1 must normally be replaced by an equal volume of air if the container 1 is not to collapse. In the embodiment shown in Figures 1*a* to 1*e*, at no stage is there a direct connection between the outlet A and the inlet E. As described above, however, during an inward stroke and in the position shown in Figure 1*d*, before discharge of liquid 23 commences, air is pushed through the inlet E into the container 1. This serves to compensate for the liquid removed during the immediately preceding pumping stroke.

The pump shown in Figures 2*a* to 2*b* is also a pump of the first kind but, in this case, the inlet E and the outlet A are provided in the piston.

The piston 205 of this pump can be secured to a container (not shown) by means of a screw cap 224. The piston 205 is provided with sealing rings 241, 243 and 244 between the outer wall of the piston 205 and the inner wall of the housing 208. The outlet A is situated in the piston wall between the sealing rings 241 and 243, and is connected *via* an outlet passage 230 to an outlet pipe 234 provided with a mouthpiece 209. The inlet E is situated in the piston wall between the sealing rings 243 and 244 and is connected *via* an inlet passage 227, which passes downward through the piston 205, to a suction pipe 210. An overflow passage 236 is provided in the housing 208. In this embodiment of a pump according to the invention, it is not the rims of the inlet E and the outlet A, but the adjacent sealing rings, that constitute the control edges. (This is also the case in the other forms of pump described below.)

When the housing is in the position shown in Figure 2*a*, the pump chamber 220 is in communication, *via* the overflow passage 236, with the outlet A, and thus with the mouthpiece 209. As the housing 208 moves upward, which is brought about by means of a return spirng (not shown), air is sucked inward through the outlet A until the sealing ring 2453 has passed the lower aperture 238 of the overflow passage 236. Upon further upward movement of the housing 208, liquid is sucked through from the container, *via* the suction pipe 210, the inlet passage 227, the inlet E and the overflow passage 236, into the pump chamber 220.

As the housing 208 is subsequently pressed downward (from the position shown in Figure 2*b*), by hand, against the force of the return spring, first air, and possibly some material from a previous pumping operation, is forced back, through the overflow passage 236, the inlet E and the inlet passage 227, into the container, until the lower aperture 238 of the overflow passage 236 has moved downward past the sealing ring 243, whereupon material and

air are discharged from the pump chamber 220 through the overflow passage 236, the outlet A, the outlet passage 230 and the mouthpiece 209, until the housing has reached the position shown in Figure 2*a*.

While the aperture 238 is moving over the sealing ring 243, there is a direct connection between the outlet A and the inlet E, and, during this time, air is able to flow in through the mouthpiece 209, around the sealing ring 243 and down into the container, to compensate for material that has been discharged.

The pump shown in Figures 3*a* to 3*c* is a pump of the first kind, in which the inlet and the outlet are both provided in the housing.

The pump includes a piston 305 to which is attached an operating button 306, which can move up and down within a guide element 322 situated on top of the housing 308. Both the guide element 332 and the housing 308 are provided with external flanges which may be engaged by a screw cap 324, by means of which the pump may be secured to a container with most of the pump located within the container. The housing 308 is provided with an inlet E, which is connected *via* an inlet passage 326 to a suction pipe 310. The housing 308 is also provided with an outlet A, which is connected *via* an outlet passage 328 within the housing 308 and an outlet passage 329 within the guide element 322 to a mouthpiece 309. The piston 305 includes an overflow passage 312, the upper end of which communicates with the outer wall of the piston *via* a transverse passage 218, the lower part 332 of which is widened and houses a return spring 354, and the lower end of which communicates with the pump chamber 320. The piston 305 is provided with four sealing rings 341, 342, 343 and 344, located between the outer wall of the piston 305 and the inner wall of the housing 308. The positions of the sealing rings 341 to 344 along the length of the piston 305, the position of the transverse passage 318, and the positions of the inlet E and the outlet A are decisive for the operation of the pump, as will be apparent from the description below.

The operation of the pump will now be described, starting from the innermost (lowermost) position of the piston (Figure 3*a*), which position is determined by the lower edge of the operating button 306 abutting against the base plate of the guide element 322. With the piston in this position, the pump chamber 320 is in communication with the outlet A. As the piston moves upward, first air is sucked in through the mouthpiece 309, the outlet passages 329 and 328 and the outlet A thus removing any material from these parts, and both air and liquid pass througy the overflow passage 312 into the pump chamber 320. This ceases when the sealing ring 342 passes upward over the upper rim of the outlet A (Figure 3*b*). At this stage, there is direct communication between the outlet A and the inlet E (which permits aeration of the container to which the pump is attached) and the pump chamber 320 is completely closed off from the outside, so that further upward movement of the piston 305 results in a reduced pressure developing within the pump chamber 320. On further upward movement of the piston 305, the sealing ring 344 passes the inlet E; as soon as this happens the pump chamber 320 is in communication with the inlet E and liquid is abruptly sucked from the container, *via* the suction pipe 310, into the pump chamber 320. This sucking operation continues until the piston has reached its uppermost position, which is also its rest position and which is determined by the upper end of the piston 305 abutting against the base plate of the guide element 322 (Figure 3*c*). In this position, the outlet A is closed off from the pump chamber 320 by the piston 305. Although the inlet E is in communication with the pump chamber 320, there is no danger of spillage, because the transverse passage 318 is sealed off by the inner wall of the housing 308, and thus liquid cannot reach the outlet A.

As the piston 305 is depressed, first air, and possibly some liquid, is conveyed from the pump chamber 320, *via* the inlet E, back into the container, until the lowermost sealing ring 344 seals off the pump chamber 320 from the inlet E (Figure 3*b*). The inlet E and the outlet A are again in direct communication with one another and air can enter the container to replace the liquid previously sucked into the pump chamber 320. As the piston 305 is depressed further, the air in the pump chamber 320 and in the passages 332, 312 and 318 is compressed. As soon as the sealing ring 342 has passed downward over the upper rim of the outlet A, the pump chamber 320 is in communication with the outlet A, and air and liquid are abruptly discharged through the outlet A, the outlet passages 328 and 329 and the mouthpiece 309.

The pump shown in Figures 4*a* to 4*c* is similar to that shown in Figures 1*a* to 1*e*, except that it is provided with sealing rings.

The piston 405 of this pump is provided at its outer end with an operating button 406 and within the piston 405 are an overflow passage 412 and two transverse passages 416 and 418 (*cf.* the pump shown in Figures 1*a* to 1*e*). The overflow passage 412 terminates in a recess 432 in the inner end face of the piston, which recess 432 is in direct communication with the pump chamber 420. Five sealing rings 440 to 444 are arranged around the piston 405 to form seals between the outer wall of the piston 405 and the inner wall of the housing 408. At the inner end of the piston 405, the piston diameter increases slightly such that a portion of the wall 445 fits snugly within the housing 408. The housing 408 includes an inlet E in communication with a suction pipe 410 containing an inlet passage 426, and also includes an outlet A in communication with an outlet nozzle 452 and a mouthpiece 409. The inlet E and the outlet A are spaced apart longitudinally (contrast the pump shown in Figures 1*a* to 1*e*). A return spring 454 acting against the outlet nozzle 452 serves to urge the piston 405 to its outermost position (which is its rest position (as shown in Figure 4*c*). Means not shown prevent the piston 405 from moving beyond this position. The innermost position of the piston is shown in Figure 4*a* and an intermediate position is shown in Figure 4*b*. The operation of this pump is similar to that of the pump shown in Figures 1*a* to 1*e*, and therefore need not be described in detail here.

In all the pumps described above with reference to the drawings, the inlet E and the outlet A are located either both in the pump housing or both in the pump piston, and the outlet mouthpiece 9, 209, *etc.* remains stationary, relative to the container, during the pumping operation. These pumps are referred to as "pumps of the first kind". Pumps will now be described in which the inlet E is provided in the housing and the outlet A is provided in the piston and consequently follows the movement of the piston. In these pumps, the mouthpiece 509, *etc.* therefore moves relative to the container, during the pumping operation. These pumps are referred to as "pumps of the second kind".

The pump shown in Figures 5.1 and 5.2 is a pump of the second kind arranged within a pistol-like top for attachment to a container. Part of the pistol-like top constitutes the housing 508 of the pump and includes a cylindrical bore 566 containing the piston 505. A stop plate 558 arranged in grooves in the housing 508 serves to prevent the piston 805 from moving outward beyond the position shown in Figure 5.2 and a helical spring 554 arranged in a groove 560, in the lower side of the piston and acting against the stop plate 558 serves to urge the piston into this position, which is its rest position. The stop plate 558 also engages in the groove 560 and thereby prevents the piston from turning about its longitudinal axis. A finger rest 562 in the form of a trigger, by means of which the piston 505 may be pulled inward against the action of the spring 554, is rigidly secured to the outer end of the piston 505, which is also provided with a mouthpiece 509. The housing 508 is secured to the neck of the container 501 by means of a screw cap 524. The piston is provided with four sealing rings 541 to 544 (*cf.* Figures 3*a* to 3*c*). A passage 512 extends longitudinally within the piston 505 from its inner end face to a transverse passage 518, which opens through the top outer wall of the piston between the sealing rings 542 and 543. An outlet passage 530, separated from the passage 512 by a transverse wall 566, also extends longitudinally within the piston 505 and connects the outlet A, which is situated between the sealing rings 541 and 542, with the mouthpiece 509. The inlet E is situated in the housing 508 and is in communication with an inlet pipe 510. A recess 570, formed by partially plugging a transverse bore through the housing 508, with a plug 572, is arranged in the lower side of the inner wall 521 of the housing.

In this pump, the four sealing rings 541 to 544, the rims of the recess 570 and the rims of the inlet E constitute control edges. The recess 570 cooperates with the two sealing rings 452 and 543 whilst the two end sealing rings 541 and 544 provide the two outer piston seals and never pass into the vicinity of the recess 570.

Various modifications that may be made to the piston 505 of the pump shown in Figures 5.1 and 5.2 are shown in Figures 5.3 to 5.6.

Instead of the piston being provided with sealing rings, as shown in Figures 5.1 and 5.2 and in previous figures, a plastics sleeve 574 fitting snugly around the piston 505′ may be provided with ridges to constitute the four annular seals 541 to 544 (Figure 5.3). Alternatively, the piston 505 may be provided with ridges to constitute the annular seals 541 to 544, which, since they will then consist of hard material, may be covered by a resilient sleeve 575 (Figure 5.4). Moreover, instead of being of semi-circular cross-section, the annular seals 541′ to 544′ may be of approximately triangular cross-section (Figure 5.6), may extend backward (that is toward the pump chamber), preferably at an angle of less than 45° and may terminate at a fine edge. Such seals may be provided on a sleeve 574′ (*cf.* Figure 5.3). The use of this type of seal ensures that a reliable seal is maintained during the pressure stroke, that is, during inward movement of the piston.

(Modifications similar to those shown in Figures 5.3, 5.4 and 5.6 can also be used with the other pumps shown with sealing rings.)

A further modification to the piston of the pump shown in Figures 5.1 and 5.2 is shown in Figure 5.5. This modification can result in improved mixing of air and liquid within the pump. In this modification, the passage 512 of the piston 505′′′ contains a stopper 576 the outer surface of which is provided with a helical groove 578 (both ends of which are on the upper side of the piston 505′′′) and with a longitudinal passage 580, (which extends the whole length of the stopper 576) at the lower side of the piston 505′′′.

The pump shown in Figures 5*a* to 5*f* is very similar to that shown in Figures 5.1 and 5.2, and its operation will now be described, starting from the innermost position of the piston (Figure 5*a*). Shortly after the commencement of the outward movement of the piston 505, the sealing ring 542 passes the left-hand edge of the recess 570 (Figure 5*b*), whereupon, for a short portion of the stroke, air can enter the container through the mouthpiece 509, through the outlet passage 530, the outlet A, the recess 570, the inlet E, and the inlet pipe 510. (This is possible only because the distance between the sealing rings 542 and 543 is greater than the distance between the right-hand edge of the inlet E and the left-hand edge of the recess 570. If, on the other hand, the first-mentioned distance were smaller than the second-mentioned distance, direct aeration of the container would not be possible. In that case, replacement air would be merely conveyed from the pump chamber 520 into the container during inward movement of the piston in the portions of the stroke shown in Figures 5*f*, 5*e* and 5*b*.) Once the sealing ring 543 has passed the inlet E (Figure 5*c*), this connection through to the container is sealed off. Air is then sucked through the mouthpiece 509, the outlet passage 530, the outlet A, the recess 570, the transverse passage 518 and the passage 512 into the pump chamber 520, thus removing any liquid from a preceding pumping operation from the mentioned parts. When the sealing ring 542 has passed the right-hand edge of the recess 570 (Figure 5*d*), the pump chamber 520 is sealed off by the two sealing rings 542 and 543 from both the inlet E and the outlet A, and thus further outward movement of the piston 505 produces a reduced pressure within the pump chamber 520. (This happens only when the two sealing rings 542 and 543 are situated on opposite sides

of the recess 570 and because the distance between these sealing rings 542 and 543 is greater than the length of the recess 570. Thus, whether a reduced pressure is formed and, if so, the portion of the stroke over which it is formed can be altered by varying the positions of the sealing rings 542 and 543.) When the sealing ring 543 has passed over the left-hand edge of the recess 570 (Figure 5*e*), and on further outward movement of the piston 505, liquid is sucked from the container, through the inlet pipe 510, the inlet E, the recess 570, the transverse passage 518 and the passage 512 into the pump chamber 520. This sucking action continues after the sealing ring 543 has passed the right-hand edge of the recess 570 because the sealing ring 544 has by then passed the inlet E (Figure 5*f*) and there is then direct communication between the inlet E and pump chamber 520. In this position, there is no communication between the inlet E and the outlet A, and the pump thus seals the container from the outside air.

As the piston 505 is pushed in, the pump moves through the reverse sequence of positions from Figure 5*f* to Figure 5*a*. During the portions of the stroke shown in Figures 5*f* and 5*e*, air and, to some extent, liquid is conveyed from the pump chamber 520 through the inlet E back into the container, until the sealing ring 543 has moved inwards beyond the left-hand edge of the recess 570 (Figure 5*d*). Pressure then builds up in the pump chamber 520 until the sealing ring 542 has passed the right-hand edge of the recess 570 (Figure 5*c*). While the sealing ring 542 is passing the recess 570, liquid and air are forced out of the pump chamber 520 through the passage 512, the transverse passage 518, the recess 570, the outlet A, the outlet passage 530 and the mouthpiece 509. Toward the end of this operation, there is a direct connection between the pump chamber 520, the inlet E and the outlet A (Figure. 5*b*) and, during this portion of the stroke, replacement air is able to enter the container, but the discharge of liquid and air can nevertheless continue. When the sealing ring 542 has passed the left-hand edge of the recess 570 (Figure 5*a*), the outlet A is sealed off from the pump chamber 520 and from the inlet E by the sealing ring 542. This position is the rest position of the pump. In this position, the inlet E is in communication through the transverse passage 518 with the pump chamber, which is here reduced to the volume of the passage 512.

It can be seen that, in both end positions (Figures 5*a* and 5*f*), the pump thus serves to seal the container from the outside air.

The pump shown in Figure 6 is a pump of the second kind suitable for being arranged vertically on a container. The pump includes an operating button 606 suitable for actuation by a finger, which button is provided with a mouthpiece 609 and moved within guide elements provided on a screw cap 624 for attachment of the pump to a container (not shown). A large part of the pump is located beneath the screw cap 624 and thus projects into the container, which means that the overall height of a unit consisting of the pump and the container is reduced. The pump also includes a helical pressure spring 654 arranged to urge the piston 605 upward into its rest position (as shown). An inlet passage 626 extending vertically downwards is provided in the housing 608, and an outlet passage 630 extending vertically upwards is provided in the piston 605. Other elements of the pump are similar to those of the pump shown in Figures 5*a* to 5*f*, and the pump operates in a manner similar to that of the pump shown in Figures 5*a* to 5*f*.

The pump may be adapted for use upside-down, for example to spray liquids underneath pieces of furniture or to discharge foot powder. In this case, the stopper 684 and the inlet pipe 610 are removed and the end of the inlet passage 626 may be closed by a stopper (not shown) replacing the inlet pipe 610. (Other pumps shown may also be modified for use upside-down.)

The pump shown in Figure 7 is another pump of the second kind and is similar, from an operational viewpoint, to those shown in Figures 5.1 and 5.2, 5*a* to 5*f*, and 6. A spring (not shown) is provided within the passage 712 to urge the piston from the position shown into its outermost position, which is also its rest position. The housing of the pump consists of an inner housing 708 and an outer housing 786. (This means that the various passages and recesses can readily be formed by gaps between the inner and outer housings.) An annular space 788 is provided between the two housings and a radial aperture extends from this space 788 through the inner housing to form a recess 770. A longitudinal groove in the inner housing 708 constitutes an inlet passage 726.

The pump shown in Figures 8*a* and 8*b* is another pump of the first kind and operates in a manner similar to that in which the pump shown in Figures 3*a* to 3*c* operates, but with the essential difference that actuation of the pump is effected by a trigger mechanism rather than by a push-button. The outermost position of the piston, which is the rest position, is shown in Figure 8*a* and the innermost position is shown in Figure 8*b*. A trigger housing 888 is firmly attached to the upper end of the housing 808 and a trigger lever 887 is pivotally mounted therein about an axis 889. An articulated lever unit 890 serves to conver tthe pivotal movement of the trigger lever 887 into a vertical piston movement. This unit 890 consists of a Y-shaped member made of a resilient plastics material and having three arms 891, 892 and 893 flexibly joined together. The outer ends of the arms 891 and 893 are fastened to the trigger lever 887 and the piston 805 respectively, whilst the outer end of the arm 892 is braced in an inner corner of the trigger housing 888. The method of operation of the unit 890 can be seen clearly from the drawings. The trigger housing 888 also contains a tube 829 which connects the outlet passage 828 with the mouthpiece 809.

It will be apparent that various modifications may be made to the pumps shown to alter various aspects of their operation. For example, some of the pumps shown may be operated in a wide variety of positions, such as horizontally, upright or upside-down, while other pumps may be modified in order to render them suitable for operation in positions other than those shown.

The ratio of the internal diameter of the pump

chamber to the smallest diameter of the outlet may be varied in order to vary the amount of material discharged per stroke. The higher is the said ratio, the greater is the amount of material discharged per stroke. When discharging relatively large amounts of material per stroke, it can be advantageous to use a trigger mechanism such as that shown in Figure 8.

The sealing rings may be dispensed with (*cf*. Figures 1*a* to 1*e*) if the piston fits snugly within the housing over its entire length. Generally, however, it is advantageous to use sealing rings. These may be provided in many different ways, as will be apparent from Figures 5.3, 5.4 and 5.6. Moreover, they may be provided on the piston or on the inner wall of the housing. They may be provided by forming grooves in the piston and/or the housing so that the ridges remaining between the grooves serve as seals.

The ratio of material to air in the discharged mixture can be altered by changing the positions of the seals or other control edges. For example, if the control edges are so arranged that the outlet is connected to the pump chamber for a relatively long portion of the stroke, while the inlet is connected to the pump chamber for a relatively short portion of the stroke, the pump will discharge a mixture having a relatively high proportion of air and a relatively low proportion of liquid. The converse is also true. When the production of a liquid mist is desired, a mixture having a high proportion of air should be discharged, whereas when it is desired to discharge as much liquid as possible per stroke, for example, as a jet, then the pump is adjusted to supply a small proportion of air.

The magnitude of a reduced pressure or excess pressure formed during a portion of the stroke can also be altered by changing the positions of the control edges.

In the pumps of the second kind having a movable outlet, such as those shown in Figures 5.1, 5.2, 5*a* to 5*f*, 6 and 7, only four annular seals are required. When the piston is in its innermost position, the annular seals or sealing rings 541, 641 or 741 should seal off the recess 570, 670 or 770 from the outside air (*cf*. Figure 5*a*). When the piston is in its outermost position, the annular seals or sealing rings 542 *etc.* should lie inwards of the recess 570 *etc*. so that the outlet is sealed off from the pump chamber 520 *etc*, and the inlet E (*cf*. Figure 5*f*). The distance between the outermost ring 542 *etc*., and the innermost ring 544 *etc*. determines the minimum length of the pump chamber 520 *etc*.

Positions such as that shown in Figure 5*d* in which the sealing rings 542 and 543 form a seal on both sides of the recess 570 and in which the inlet E is sealed off by the two sealing rings 543 and 544, result in the formation of an excess pressure or a reduced pressure in the pump chamber 520, as the piston is moved, and provided these seals remain air tight. If the pump chamber were completely filled with liquid during this portion of the stroke, then, because of the incompressibility of liquids, further piston movement would be impossible and thus the pump would become inoperable. If, therefore, the rings are so arranged that the formation of an excess pressure or a reduced pressure is possible, care should be taken that in addition to liquid, there is always some air in the pump chamber. Alternatively, resilience may be provided in another manner, for example by providing the housing or the piston with a flexible wall or by including solid compressible material, for example a piece of sponge material having closed pores, in the pump chamber. As a further alternative, a leakage flow of sufficient size may be permitted in order to maintain the pressure balance.

The recess 570 *etc*. should be sufficiently long for an adequate amount of material to pass from the pump chamber to the outlet around the sealing ring 542 during the relevant portion of the stroke. If it is desired to increase the amounts of material to be discharged, this can be effected by lengthening the recess 570, *etc*. Alternatively, the sealing ring 542 may be moved toward the outer end of the piston, thus prolonging the compression phase prior to actual discharge, with the result that on opening the recess 570 *etc*. the liquid is abruptly forced to the outlet because of the excess pressure which has built up.

Moreover, if, for a given overall length of the interior of the housing, the distance between the rings 542 *etc*. and 543 *etc.* is increased, the portion of the stroke during which excess pressure is produced as the piston is pushed in is lengthened and the actual discharge time is reduced. The converse is also true.

The pumps shown in Figures 2*a* and 2*b*, 3*a* to 3*c*, 4*a* to 4*c*, and 8*a* and 8*b* are pumps of the first kind and the outlet is stationary with respect to the container. In such pumps, only three annular seals are required: the sealing ring 342 *etc*. may be dispensed with, provided that it is not intended to produce an excess or reduced pressure during the pumping operation. When the piston is in its innermost position, the outermost sealing ring 341 *etc*. should be situated outward of the outlet A and when the piston is in its outermost position the innermost sealing ring 344 *etc*. should be situated outward of the inlet E. The distance between the sealing rings 341 and 344 *etc*. determines the minimum length of the inner space 356 *etc*. of the housing. If, on the other hand, the sealing ring 342 *etc.* is present, provision must be made, whenever an excess or reduced pressure can be produced, for resilient means, as described above, to prevent liquid from blocking the pump. The amount of material discharged per stroke is determined by the position of the sealing ring 342 *etc*.

From a comparison of the pump shown in Figures 3*a* to 3*c* with that shown in Figures 4*a* to 4*c*, it may be seen that the sealing rings 441, 444 and 445 and the transverse passage 416 could be dispensed with. Moreover, if the production of an excess or reduced pressure during the pumping action is not desired, the sealing ring 442 could also be dispensed with. The sealing ring 445 merely serves to prevent communication between the pump chamber 420 and the inlet E when the piston is in its outermost position, thus preventing material from passing between the pump chamber and the container while the pump is in its rest position.

In a pump according to the invention, the interior of the housing and the piston will generally be of circular cross-section. They may, however, be of, for example, eliptical or rectangular cross-section, and the terms "sealing ring" and "annular seal" as used herein should be construed accordingly.

CLAIMS

1. A hand-operated axial piston pump suitable for discharging the contents of a container, which pump includes an inlet through which material from the container can enter the pump and an outlet through which the said material can be discharged, each of the inlet and the outlet opening through an aperture in the outer wall of the pump piston or the inner wall of the pump housing into the interior of the pump housing, wherein one or more passages opening into the interior of the pump housing and each of the inlet aperture and the outlet aperture are so arranged in the piston or in the housing that the piston and the housing form an axial piston valve whereby the inlet and outlet apertures open and close at various portions of the pump stroke and whereby, when the pump is in its rest position, there is no communication between the inlet and the outlet.

2. A pump as claimed in claim 1, wherein the relative movement between the piston and the housing is substantially purely translational movement.

3. A pump as claimed in claim 1 or claim 2, wherein, in the outermost portion of the pump stroke, there is no communication between the outlet and the pump chamber.

4. A pump as claimed in claim 3, wherein a return spring is provided which serves to urge the piston into its outermost position.

5. A pump as claimed in any one of claims 1 to 4, wherein, in the innermost portion of the pump stroke, there is no communication between the inlet and the pump chamber.

6. A pump as claimed in any one of claims 1 to 5, wherein, in one portion of the pump stroke, the inlet is in communication with the outlet through the pump chamber.

7. A pump as claimed in any one of claims 1 to 5, wherein, in one portion of the pump stroke, the outlet is in communication with the pump chamber and in a second portion of the pump stroke, which is an outer portion with respect to the first-mentioned portion, the inlet is in communication with the pump chamber.

8. A pump as claimed in claim 7, wherein, in one portion of the pump stroke, there is no communication between the outlet and the pump chamber nor between the inlet and the pump chamber.

9. A pump as claimed in claim 8, wherein a compressible medium is situated in the pump chamber or in a chamber immediately adjoining the pump chamber.

10. A pump as claimed in claim 9, wherein the compressible medium is air or is a sponge or foam material having closed pores.

11. A pump as claimed in claim 8, wherein a wall of the pump chamber or of a chamber immediately adjoining the pump chamber includes a resilient wall portion.

12. A pump as claimed in any one of claims 1 to 11, wherein the inlet and the outlet are situated both in the piston or both in the housing.

13. A pump as claimed in any one of claims 1 to 11, wherein one of the inlet and the outlet is situated in the piston and the other is situated in the housing.

14. A pump as claimed in claim 1, wherein the inlet and the outlet are situated both in either the piston or the housing and wherein a passage is provided in the other of the piston and the housing such that in one portion of the pump stroke the inlet is in communication with the pump chamber, *via* the said passage and in the same or another portion of the pump stroke the outlet is in communication with the pump chamber *via* the said passage.

15. A pump as claimed in claim 15, wherein the inlet aperture and the outlet aperture are offset longitudinally with respect to one another.

16. A pump as claimed in claim 14 or claim 15, wherein the inlet and the outlet are both provided in the housing and wherein the said passage extends longitudinally within the piston from the pump chamber to two apertures in the side wall of the piston, one passage aperture for communication with the inlet aperture in one portion of the pump stroke and the second passage aperture for communication with the outlet aperture in the same or another portion of the pump stroke.

17. A pump as claimed in claim 14 or claim 15, wherein the inlet and the outlet are both provided in the housing and wherein the said passage extends longitudinally within the piston from the pump chamber to an aperture in the side wall of the piston, which aperture communicates with the inlet aperture and/or the outlet aperture in various portions of the pump stroke.

18. A pump as claimed in claim 17, wherein first, second and third annular seals are provided between the outer wall of the piston and the inner wall of the housing, wherein the first seal is the outermost seal and serves to seal off the interior of the housing from the exterior of the pump in all portions of the pump stroke, wherein the passage aperture lies between the first seal and the second seal, wherein the second seal is so situated that in a first portion of the pump stroke it separates the inlet aperture from the outlet aperture, and wherein the third seal is the innermost seal and is so situated that in a second portion of the pump stroke, which is an outer portion with respect to the said first portion, it separates the inlet aperture from the outlet aperture while the inlet is in communication with the pump chamber, and that in another portion of the pump stroke, which is an inner portion, it separates the inlet aperture from the pump chamber.

19. A pump as claimed in claim 18, wherein the annular seals are provided on the piston, wherein the first and third seals are situated adjacent to the outer and inner ends of the piston respectively, and wherein, in all portions of the pump stroke, the first seal is outward of the outlet aperture.

20. A pump as claimed in claim 18 or claim 19, wherein the distance between the first and third

seals is greater than the distance between the edges of the inlet aperture and the outlet aperture that are furthest from one another.

21. A pump as claimed in any one of claims 18 to 20, wherein the distance between the first and second seals is less than the distance between the edges of the openings of the inlet aperture and the outlet aperture that are furthest from one another.

22. A pump as claimed in any one of claims 18 to 21, wherein the second and third seals are so situated that, in one portion of the pump stroke, while the third seal seals off the inlet aperture from the pump chamber, the inlet is in communication with the outlet.

23. A pump as claimed in any one of claims 18 to 22, wherein a fourth seal is provided between the third seal and the passage aperture.

24. A pump as claimed in any one of claims 17 to 23, wherein the said passage connects with a second aperture in the side wall of the piston, which second aperture is situated between the first aperture and the inner end of the piston.

25. A pump as claimed in claim 24 as appendant to claim 18, wherein the second aperture is situated between the second and third annular seals.

26. A pump as claimed in claim 15, wherein the inlet aperture and the outlet aperture are both provided in the side wall of the piston, the two apertures being offset longitudinally with respect to one another, wherein a passage extends longitudinally within the housing from the pump chamber to an aperture in the inner wall of the housing, and wherein, in a first portion of the pump stroke, the outlet is in communication with the said passage and, in a second portion of the pump stroke, which is an outer portion with respect to the first portion, the inlet is in communication with the said passage and there is no communication between the outlet and the said passage.

27. A pump as claimed in claim 26, wherein three annular seals are provided on the piston in such positions that the inlet aperture is situated between the innermost and middle seals and the outlet aperture is situated between the outermost and middle seals.

28. A pump as claimed in claim 1, wherein the inlet and the outlet are provided one in the piston and the other in the housing, and wherein a passage or recess, each opening into the interior of the housing is provided in each of the piston and the housing, such that in one portion of the pump stroke the inlet is in communication with the pump chamber and in the same or another portion of the pump stroke the outlet is in communication with the pump chamber.

29. A pump as claimed in claim 28, wherein one passage extends through the piston or housing from the pump chamber to an aperture opening into the interior of the housing, and a second such passage extends through the other of the piston and the housing and connects two apertures opening into the interior of the housing.

30. A pump as claimed in claim 28, wherein one passage extends through the piston or housing from the pump chamber to an aperture opening into the interior of the housing, and a recess is provided in the wall of the other of the piston and the housing.

31. A pump as claimed in claim 28, wherein one passage extends longitudinally through the piston from the pump chamber to an aperture in the wall of the piston and a recess is provided in the wall of the housing.

32. A pump as claimed in claim 31, wherein the inlet or the outlet opens through an aperture in the wall of the piston.

33. A pump as claimed in claim 31, wherein the outlet opens through the piston.

34. A pump as claimed in claim 33, wherein the recess is so arranged that in one portion of the pump stroke the passage aperture is in communication with the outlet aperture *via* the recess.

35. A pump as claimed in claim 34, wherein in a second portion of the pump stroke the passage aperture is in communication with the inlet aperture *via* the recess.

36. A pump as claimed in claim 35, wherein a third portion of the pump stroke the inlet aperture is in communication with the outlet aperture *via* the recess.

37. A pump as claimed in any one of claims 28 to 36, wherein at least four annular seals are provided between the outer wall of the piston and the inner wall of the housing.

38. A pump as claimed in claim 37, wherein the annular seals are provided on the piston.

39. A pump as claimed in claim 38 as appendant to claim 33, wherein the first and fourth annular seals are situated adjacent to the outer and inner ends of the piston respectively, wherein the outlet aperture is situated between the first and second annular seals, and wherein the passage aperture is situated between the second and third annular seals.

40. A pump as claimed in claim 39, wherein, in all portions of the pump stroke, the first annular seal is outward of the recess and the fourth annular seal is inward of the recess.

41. A pump as claimed in claim 39 or claim 40, wherein the distance between the first and third annular seals is greater than the distance between the edges of the inlet aperture and the recess that are furthest from one another.

42. A pump as claimed in any one of claims 39 to 41, wherein the distance between the second and third annular seals is greater than the distance between the edges of the inlet aperture and the recess that are nearest to one another.

43. A pump as claimed in any one of the preceding claims, wherein the housing comprises an inner housing fitted snugly within an outer housing, with any apertures, recesses and/or passages in the housing being constituted by bores and/or grooves in the inner housing and/or by gaps between the inner and outer housings.

44. A pump as claimed in any one of claims 18 to 23, 25, and 37 to 42, wherein the annular seals are constituted by sealing rings.

45. A pump as claimed in any one of claims 19, 20 to 24 as appendant to claim 19, and 38 to 42, wherein the annular seals are constituted by ridges on the outer wall of the piston.

46. A pump as claimed in any one of claims 19, 20 to 24 as appendant to claim 19, and 38 to 42,

wherein a plastics sleeve fits snugly around the piston and is provided with ridges constituting the annular seals.

47. A pump as claimed in claim 46, wherein the ridges are of approximately semi-circular cross-section.

48. A pump as claimed in claim 46, wherein the ridges are of approximately triangular cross-section and extend backward to a fine edge.

49. A pump as claimed in claim 1, substantially as described herein with reference to, and as shown in Figures 1*a* to 1*e*, or Figures 2*a* and 2*b*, or Figures 3*a* to 3*c*, or Figures 4*a* to 4*c*, or Figures 5.1 and 5.2, or Figures 5*a* to 5*f*, or Figure 6, or Figure 7, or Figures 8*a* and 8*b* of the accompanying drawings.

50. A unit comprising container with a pump as claimed in any one of claims 1 to 49 secured thereto by whichever of the pump housing and the pump piston contains the inlet, the inlet being in communication with the interior of the container.

51. A unit as claimed in claim 50, wherein the pump can be actuated by a push-button attached to or constituted by whichever of the pump piston and the pump housing is not secured to the container.

52. A unit as claimed in claim 50, wherein the pump can be actuated by a trigger attached to or constituted by whichever of the pump piston and the pump housing is not secured to the container.

53. A unit as claimed in claim 50, wherein the pump can be actuated by a trigger mechanism including means for converting the pivotal movement of the trigger to movement of the piston or housing.

54. A unit as claimed in claim 53, wherein the said means comprises a Y-shaped member of a resilient plastics material having three arms flexibly joined together, with one arm secured to the trigger, one arm secured to the piston or housing, and one arm secured to a mounting.

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